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a. NAME *(Last, First, Middle Initial)*	b. RANK	c. TITLE
Kudo, Rance	Civ	
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4. POINT OF CONTACT

a. NAME *(Last, First, Middle Initial)*	b. TELEPHONE NO. *(Include Area Code)*
Banks, Betty	(703) 696-2126

5. PRIOR COORDINATION

a. NAME *(Last, First, Middle Initial)*	b. OFFICE/AGENCY	c. TELEPHONE NO. *(Include Area Code)*
Boyd, Robert	ODDR&E (BioSystems)	(703) 588-7401

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ESTCP
Cost and Performance Report

(PP-0026)

Universal Stationary/Mobile NoFoam Unit (USNOFU) for Aircraft Rescue and Fire Fighting (ARFF) Vehicles

January 2004

ENVIRONMENTAL SECURITY
TECHNOLOGY CERTIFICATION PROGRAM

U.S. Department of Defense

COST & PERFORMANCE REPORT
ESTCP Project: PP-0026

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF FIGURES

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

AFB	Air Force Base
AFFF	aqueous film forming foam
AFRL	Air Force Research Laboratory
ARFF	Aircraft Rescue and Fire Fighting
BOD	Biological Oxygen Demand
CFR	Crash Fire Rescue
COD	chemical oxygen demand
DoD	Department of Defense
ECAM	Environmental Cost Analysis Methodology
EPA	Environmental Protection Agency
ESTCP	Environmental Security Technology Certification Program
gpm	gallons per minute
MCAF	Marine Corps Air Facility
NAS	Naval Air Station
NAVFAC	Naval Facilities Engineering Command
NDCEE	National Defense Center for Environmental Excellence
NFESC	Naval Facilities Engineering Service Center
NFPA	National Fire Protection Association
NSF	National Sanitation Foundation
OEM	original equipment manufacturer
PBT	persistent, bioaccumulating, and toxic
PFOS	perfluoro-octanyl sulfonates
PPEP	Pollution Prevention Equipment Program
USNOFU	Universal Stationary/mobile NoFoam Unit

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The Environmental Security Technology Certification Program (ESTCP) is gratefully acknowledged for its financial support demonstrating and validating the NoFoam Unit for the Aircraft Rescue and Fire Fighting (ARFF) vehicles technology at MCAF Quantico, Virginia, at Tyndall AFB, Florida, at NAS Fallon, Nevada, and at Fort Benning, Georgia.

Acknowledgement goes to the following demonstration and validation platform host activity sites for participating, collecting, and reporting the discharge data, and for the use of their ARFF vehicles.

- MCAF Quantico, Virginia — CWO3 Rafael Dominguez, Sgt. Robert Patterson and the crew of the ARFF Branch on ARFF vehicle Quantico 5 (vehicle Register No. 276001).

- Air Force Research Laboratory, Fire Research Group, Tyndall AFB, Florida — Jennifer Kalberer, Bill Fisher, Alfred Savejs, and Chuck Risinger on detachment Red Horse 5 vehicle (Register No. 84L-1229) and CAFS vehicle (vehicle Register No. 85L-1096).

- NAS Fallon, Nevada — Fire Chief Gary Pirkle, Battalion Chief Steven Hutchens, Captain Brian Kirk, Wesley Hugges, and the fire fighters on ARFF vehicle Fallon 22 (Register No. 71-03028), Fallon 23 (Register No. 71-02895), Fallon 24 (Register No. 71-02923), Fallon 26 (vehicle Register No. 71-2987), and Fallon 27 (Register No. 71-02980).

- Fort Benning, Georgia — Fire Chief Arthur Simmons, District Chief Kenneth Nickerson, Captain Harold Kelley, and the fire fighters on ARFF vehicle K34A and K34B.

Acknowledgement also to Ray J. Cappillino and Jesse L. McNolty of the Naval Facilities Engineering Service Center (NFESC), Port Hueneme, California, for fabricating, installing, and testing the NoFoam Unit for ARFF vehicles, and the NFESC implementation team.

The accomplishments made through this project would not have been possible without the enthusiasm and support from these individuals and their organizations.

Technical material contained in this report has been approved for public release.

1.0 EXECUTIVE SUMMARY

Fire-fighting guidelines and polices require regular discharge checks on all Aircraft Rescue and Fire Fighting (ARFF) vehicles to ensure that each vehicle's onboard foam distribution system is functioning properly. These regular foam distribution system checks use a fire-fighting agent called aqueous film forming foam (AFFF) and generate significant amounts of AFFF wastewater. Despite its wide use and effectiveness, AFFF poses an environmental concern and raises questions about its long-term continued use because of high biological oxygen demand (BOD), high chemical oxygen demand (COD), and its extreme foaming capability. Also, the U.S. Environmental Protection Agency (EPA) has expressed concern in regard to perofluoro-octyl sulfonate (PFOS). PFOS is an active ingredient that makes AFFF an effective fire-fighting agent, but it has been classified as persistent, bioaccumulative, and toxic (PBT). As a result, the AFFF wastewater resulting from foam distribution system checks can cause environmental hazard or damage.

Besides the environmental concerns of AFFF wastewater discharges into the environment, the extreme foaming capacity of AFFF makes the recovery and treatment of spent AFFF difficult. In some regions, Department of Defense (DoD) activities are no longer allowed to discharge AFFF wastewater to industrial waste treatment plant facilities because of the potential for plant upsets. Hence, the costs for hazardous waste handling and the collection and disposal of AFFF wastewater are burdensome and disposal is a liability.

Because of these environmental concerns and the prohibitive disposal and treatment costs of AFFF wastewaters, some activity fire departments are not performing the required regular discharge checks. This failure to perform the required checks is jeopardizing and, in some cases, prohibiting the fire fighters from meeting their mission requirements.

In this Environmental Security Technology Certification Program (ESTCP) project, the NoFoam Unit System for ARFF vehicle technology was deployed and operated at four DoD host activities. The objective was to verify the effectiveness of the technology on similar and on different ARFF vehicle models. The technology was evaluated at Marine Corps Air Facility (MCAF) Quantico, Virginia, on a P19, at Tyndall Air Force Base (AFB), Florida, on two P19s, at Fort Benning, Georgia, on a P19 and a P300, and at Naval Air Station (NAS) Fallon, Nevada, on three CF4000L and two TA3000 ARFF vehicles.

The project demonstrated that the NoFoam Unit technology for ARFF vehicles is a highly reliable and viable diagnostic tool. The NoFoam Unit can verify that the vehicle onboard foam distribution system is functioning properly without generating AFFF wastewater during the foam discharge checks. The units operated without incident and allowed the operators to discover previously unknown foam distribution system deficiencies. Two installations installed the NoFoam Unit retrofit modules on all their ARFF vehicles. One facility installed their ARFF vehicle inventory during the demonstration and validation period. The other activity installed the modules at the completion of the demonstration and validation period.

Cost estimates showed an annual disposal cost savings of $52,000 per vehicle based on weekly testing. This translates to more than $62 million annual savings for DoD's 1,200 ARFF vehicle

inventory. Additionally, approximately $1 million dollars will accrue in cost avoidance because facilities will not have to purchase AFFF concentrate presently wasted during system checks. This estimate is based on 2.2 gallons of AFFF concentrate per vehicle nozzle discharge check at $7 per gallon. This translates to a payback period of 2-3 months on a $22,000 capital investment.

The expected DoD benefits include the elimination of ARFF vehicle nozzle discharges of AFFF wastewater onto the ground or to natural or domestic water systems, and of AFFF wastewater collection and disposal during system checks. Since the NoFoam Unit eliminates the environmental concern, fire chiefs and fire fighters can perform the required vehicle foam distribution system discharge checks and training with the confidence that their fire-fighting equipment will function properly when required and will allow them to perform their mission. Furthermore, the NoFoam Unit will enhance the facility's ability to comply with local pollution and waste minimization regulations.

2.0 TECHNOLOGY DESCRIPTION

2.1 TECHNOLOGY DEVELOPMENT AND APPLICATIONS

The NoFoam Unit or NoFoam System evolved out of the NoFoam Kit for ARFF vehicles. In 1996, the Naval Facilities Engineering Command (NAVFAC) funded the Naval Facilities Engineering Service Center (NFESC) to develop and demonstrate a prototype Foam-Free, Dye-Water Test Kit technology (Kudo and Lee, 1997). The Test Kit was developed and designed for a CF4000L model ARFF vehicle to be installed in the onboard ARFF vehicle foam distribution system. It provided a conceptual method to eliminate the AFFF wastewater generated from the ARFF vehicle routine discharge checks on the foam distribution system. The discharge system consists of piping, valves, pump, proportioner, (or multimetering valve), eductor, and nozzles. The AFFF concentrate tank is isolated. An environmentally benign fluid surrogate, water or dye-water, is used to check the onboard ARFF vehicle foam distribution system. These tests are required to validate the readiness of the fire-fighting equipment.

In 1998, the Chief of Naval Operations' Pollution Prevention Equipment Program funded NFESC to develop and demonstrate the Foam-Free, Dye-Water Test Kit on an additional ARFF vehicle—model P19 (Kudo and Lee, 1998). This, like the CF4000L model ARFF vehicle, provided the fire chiefs at the facility a means of validating the readiness of their fire-fighting equipment.

In 1999, NFESC and Concurrent Technologies Corporation were tasked to determine the feasibility of applying the NoFoam Kit concept for yet another ARFF vehicle—model TA3000. Like the previous two ARFF vehicle models, CF4000L and P19, these vehicles provided the fire chiefs at the activity a means of validating the readiness of their fire-fighting equipment.

Although these three vehicle models of NoFoam Kits were effective in reducing the generated AFFF wastewater, the NoFoam Kits did not quite meet the facility's requirements. A small quantity of AFFF wastewater was generated since the residual AFFF concentrate left in the foam distribution piping system was not drained prior to the foam distribution system discharge checks.

This ESTCP project went a step further to extend the development of the NoFoam Kit concept for ARFF vehicles and also made it possible for any ARFF vehicle model to use the technology. This technology is called the Universal Stationary/mobile NoFoam Unit (USNOFU) for ARFF vehicles or NoFoam Unit or NoFoam System. An added NoFoam feature is that 95% of the NoFoam Kit hardware is installed on a mobile/stationary platform instead of on the vehicle. This new NoFoam Unit will not alter the ARFF vehicle's fire-fighting capabilities. It will complement the NoFoam Kit concept developed for ARFF vehicle models CF4000L, P19, and TA3000.

2.2 PROCESS DESCRIPTION

The mobile/stationary-mounted hardware consists of a control panel with monitor, flow sensor piping, and a 400-gallon storage tank as the AFFF concentrate surrogate. The flow sensor is a

paddlewheel that measures the flow rate of the surrogate fluid as it flows from the 400-gallon storage tank to the ARFF vehicle foam distribution system. The flow sensor has no measurable head loss and is readily removable from the sensor piping system for inspection and cleaning. The surrogate fluid is either water or dye-water. The fire fighter simply drives the ARFF vehicle to the NoFoam Unit, trailer, or stationary, and attaches a hose from the unit to the vehicle. The vehicle AFFF concentrate fluid tank is isolated during the discharge testing by closing the AFFF concentrate valve. Although the AFFF concentrate valve is closed, concentrated AFFF is present downstream of the valve and this fluid must be removed. The fluid is removed by opening the vehicle's foam distribution system drain valves and collecting the fluid into a polyethylene bottle. The captured AFFF concentrate fluid is either reused or recycled. Figure 1 is the mechanical piping diagram of a P19 NoFoam Unit.

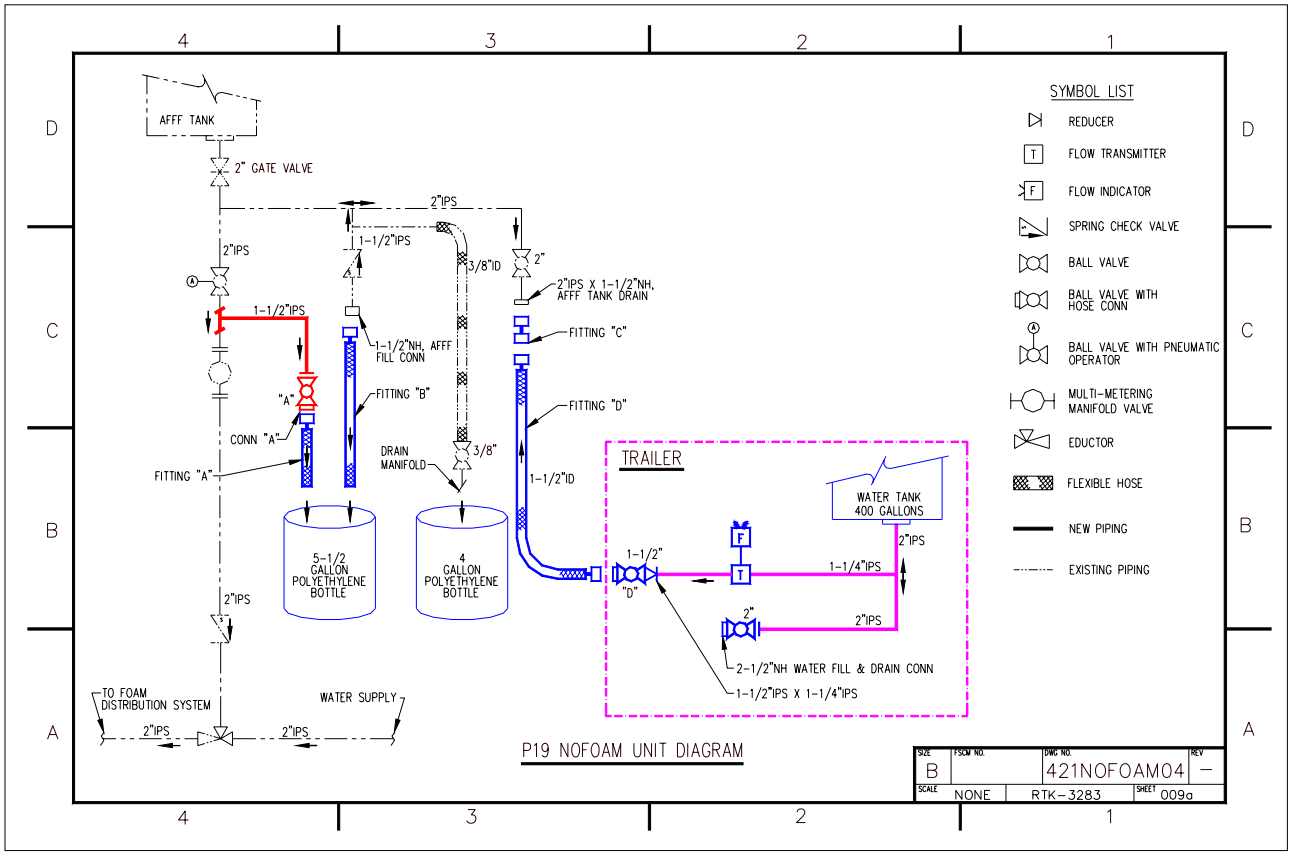

Figure 1. Piping Diagram for P19 NoFoam Unit.

The fire fighter then goes through the typical fire-fighting discharge procedures. A sensor installed in the unit measures the flow of the surrogate fluid, and the results are displayed on the rate meter in gallons per minute (gpm) (see Figure 2). The fire fighter reads the rate meter and can quickly determine the vehicle's AFFF delivery system performance. The monitored flow represents the flow rate of the AFFF concentrate into the foam distribution system. Also, the fire fighter has the option to visualize a dye-water solution discharge, giving the fire fighter a higher confidence level of the vehicle's fire-fighting performance. However, the fire fighter must still read the rate meter to verify the vehicle performance. The dye concentrate is environmentally benign, biodegradable, and certified by the National Sanitation Foundation (NSF) International (National Sanitation Foundation, 1994). The NoFoam Unit will accommodate 15 ARFF vehicles

before refilling of the 400-gallon tank is necessary and any model of ARFF vehicle with minimal vehicle airfield duty down time.

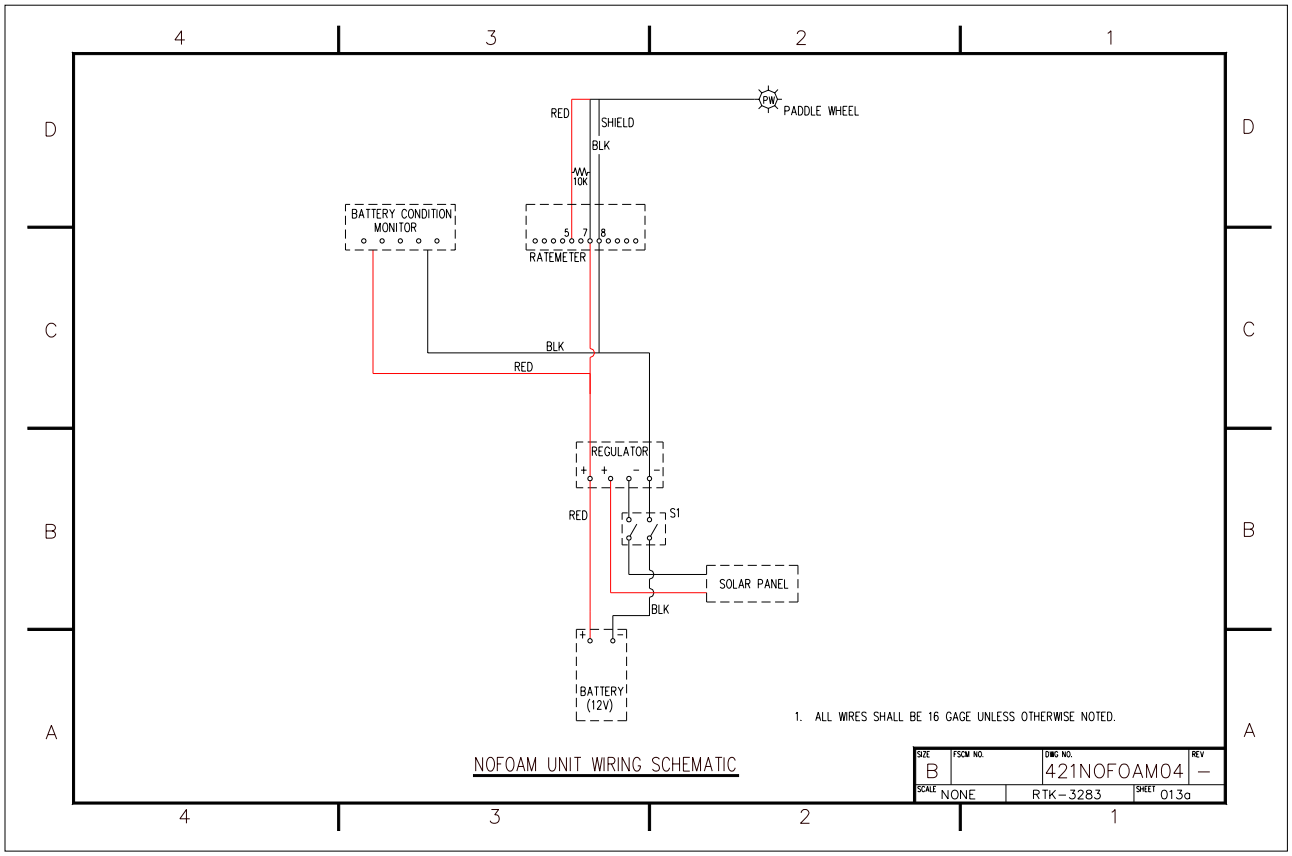

Figure 2. Wiring Schematic for NoFoam Unit.

2.3 PREVIOUS TESTING OF THE TECHNOLOGY

No previous testing of the NoFoam technology had been performed. However, the NoFoam Unit is an extension of the NoFoam Kit that NFESC designed, built, and has tested since 1996. Six naval facilities were host sites for the NoFoam Kit demonstrations. The demonstration results showed that the kit provided a method for reducing or eliminating the AFFF wastewater generated during the vehicle onboard foam distribution system discharge checks. The data collected from the demonstrations closely matched actual AFFF concentrate flows.

2.4 ADVANTAGES AND LIMITATIONS OF THE TECHNOLOGY

The NoFoam System technology has a number of advantages: it is easy to operate, requires minimal maintenance, and effectively checks the ARFF vehicle's onboard foam distribution system. The system may be mobile or stationary. The mobile system is easily moved. It can be towed with a standard 1/2 ton pick-up truck or the ARFF vehicle. Many facilities are not performing the foam distribution system checks because of the environmental concerns associated with the ARFF vehicle-generated AFFF wastewater. Since no AFFF wastewater is

generated when using the NoFoam Unit, the vehicle foam distribution system checks may be performed as required at any location the facility fire chief desires. Thus, the fire chiefs and fire fighters will have a greater confidence level in meeting their fire-fighting mission. Cost savings accrue through reduced AFFF wastewater collection and disposal, and less replenishment of the spent AFFF concentrate. The NoFoam System technology is highly applicable to the private sector.

A disadvantage to this technology is that it requires more time than the current practice to check the ARFF vehicle onboard foam distribution system. The estimated additional time required to perform the test is approximately 10 to 15 minutes per vehicle. This additional required time is to drain the AFFF concentrate from the vehicle foam distribution system prior to testing. Since the fire fighters must devote additional time to performing the vehicle foam distribution system checks, they may not readily accept the technology. However, the additional time required to drain the AFFF concentrate is probably offset by the additional time required to collect and clean-up AFFF spills if the NoFoam Unit is not used. Additionally, the NoFoam unit must be stored indoors if there is a possibility of freezing weather conditions.

3.0 DEMONSTRATION DESIGN

3.1 PERFORMANCE OBJECTIVES

The NoFoam Unit must reduce or eliminate the AFFF wastewater streams emitted from the routine nozzle discharge checks on ARFF model vehicles. This overall objective was confirmed on four models of ARFF vehicles through the use of U.S. Marine Corps, U.S. Air Force, U.S. Army, and U.S. Navy fire department ARFF vehicles. The host facilities performed weekly ARFF vehicle nozzle discharge checks. The NoFoam Unit at all four host facilities not only achieved the objective but the unit became a diagnostic tool in troubleshooting malfunctions in the vehicle foam distribution system.

3.2 SELECTION OF TEST PLATFORM/FACILITY

To select the most appropriate host facility sites for the demonstration and validation, telephone interviews were conducted with the U.S. Marine Corps, U.S. Air Force, U.S. Army, and U.S. Navy fire department personnel. The interviews were conducted to determine the models and number of ARFF vehicles at the facility; the frequency of the vehicle foam distribution system checks; the environmental concerns with the AFFF wastewater generated by the vehicle; and whether or not the facility was willing to be a host site for the demonstration and validation. A site inspection was performed on the ARFF vehicle and the facility's designated area for the vehicle foam distribution system checks.

3.3 TEST FACILITY HISTORY/CHARACTERISTICS

3.3.1 MCAF Quantico

MCAF Quantico, Virginia, is located on the banks of the Potomac River in Quantico and is hosts to Marine Helicopter Squadron ONE (HMX-1). The MCAF Quantico fire department has four P19 model ARFF vehicles. Current practice is to perform weekly nozzle discharge checks on the vehicle foam distribution system. The base environmental department has designated an area for the vehicle AFFF system checks and samples the area monthly for AFFF constituents. The minimum expected AFFF wastewater generated per vehicle is 500 gallons per week or 26,000 gallons per year. This amounts to 104,000 gallons per year for the four vehicles. Although the fire department does not collect and dispose of the AFFF wastewater, it is looking for cost avoidance by not having to purchase AFFF concentrate after every vehicle discharge checks. Also, the base environmental department is looking for alternatives for the ARFF vehicle foam distribution system discharge checks while maintaining the fire fighter mission. The airfield experiences extreme cold and hot weather conditions throughout the year.

3.3.2 Tyndall AFB

Tyndall Air Force Base, Florida, is located on the Gulf of Mexico with major units of the 325th Fighter Wing, Headquarters 1st Air Force, 475th Weapons Evaluation Group, Southeast Air Defense Sector, Air Force Civil Engineer Support Agency, and the Air Force Research Laboratory (AFRL). AFRL Air Base Technology Division develops specific technologies,

processes and models to assess and manage environmental risks associated with Air Force fire protection and crash rescue. Three P19 model ARFF vehicles are housed at the research laboratory. Current practice is to perform the vehicle foam distribution system checks on a daily or weekly schedule, depending on fire fighters' training schedules. The minimum expected generation of AFFF wastewater per vehicle is 500 gallons per week or 26,000 gallons per year, which equates to 78,000 gallons per year for three vehicles. AFRL performs the experiments, testing, and training at their EPA certified open fire pit. The AFFF wastewater is collected in a holding pond on site, and air is introduced into the wastewater to eliminate the foaming action.

Depending on AFRL recommendations, Tyndall AFB fire department may decide to use the NoFoam Unit. Three P19 model ARFF vehicles are located at the base fire department. Currently, the base fire department checks the ARFF vehicle foam distribution system weekly by discharging onto a concrete apron on the airfield. The AFFF wastewater is left to evaporate.

3.3.3 NAS Fallon

Naval Air Station Fallon, Nevada, is located 7 miles southeast of the community of Fallon and is the home of: the Naval Strike and Air Warfare Center, Fighter Squadron Composite 13, Strike Fighter Wing Detachment Fallon, and Construction Battalion Unit 416. NAS Fallon fire department has three CF4000L and two TA3000 model ARFF vehicles. Current practice is to perform weekly vehicle foam distribution system checks. The minimum expected generation of AFFF wastewater is 528 gallons for CF4000L and 1,460 gallons for TA3000. This equates to 4,504 gallons of AFFF wastewater per week for four vehicles and translates to 234,208 gallons per year for five vehicles. NAS Fallon has a certified EPA open fire pit where training and testing of the ARFF vehicles is performed. Although the fire department does not have a disposal cost for the generated AFFF wastewater, it is seeking a cost saving by not having to procure AFFF concentrate to replenish the vehicle after every foam distribution system discharge check. The airfield experiences extreme cold and hot weather conditions throughout the year.

3.3.4 Fort Benning

Fort Benning, Georgia, is located in the lower Piedmont region of central Georgia and Alabama along the Chattahoochee River. The fort supports C130, C141, C5, C17, commercial passenger aircraft up to 747s, and all types of helicopters. The fire department has one model each of P300, P19, and P4 ARFF vehicles at Lawson Army Air Field. Current practice is to check the vehicle foam distribution system weekly. The minimum expected generation of AFFF wastewater is 1,693 gallons for P300, 500 gallons for P19, and 664 gallons for P4, totaling 2,857 gallons of AFFF wastewater per week. This translates to 148,564 gallons per year for three vehicles. The tarmac next to the fire station is the designated area for the vehicle foam distribution system checks. The generated AFFF wastewater is not collected. The wastewater is left to evaporate. Although Fort Benning's fire department does not collect and dispose of the AFFF wastewater, it is seeking a cost saving by not having to procure AFFF concentrate to replenish the vehicle after every foam distribution system discharge check. Also, the fire department is aware of the environmental concerns associated with AFFF and is seeking alternatives for the routine nozzle discharge checks. The airfield experiences extreme cold and hot weather conditions throughout the year.

3.4 PHYSICAL SET-UP AND OPERATION

Each of the four host facility sites received a NoFoam Unit for the demonstrations and validations, which were conducted between March 2001 and November 2002. After a demonstration and validation period, the unit was left with the facility for continued use after the completion of the project.

NFESC personnel installed the retrofit modules on the selected ARFF vehicle models with the fire fighters and mechanics looking on. On two other occasions the facility mechanic performed the retrofit module installation—one retrofit module at one host activity and three retrofit modules at the second host activity. The fire fighter towed the NoFoam Unit trailer from storage and filled the 400-gallon surrogate tank with water and/or dye water. Then the fire fighter towed the NoFoam Unit trailer to the activity-designated site for weekly ARFF vehicle nozzle discharge checks. The fire fighter simply drove the ARFF vehicle to the NoFoam Unit trailer, and hose fittings were attached at a designated location on the ARFF vehicle (see Figure 1). The vehicle AFFF concentrate tank was isolated and the vehicle foam distribution system drain valves were opened to collect the residual AFFF concentrate left in the foam distribution system. The collected residual AFFF concentrate was recycled back into the ARFF vehicle. At this point, the NoFoam System was ready for ARFF vehicle nozzle discharge checks. One fire fighter performed the nozzle check by going through the routine foam discharge checks while another fire fighter read and recorded the surrogate flow monitor on the NoFoam Unit trailer. After completion of the nozzle discharge checks, the hose fittings were secured and the ARFF vehicle was returned to the flight line. The NoFoam Unit tank was drained and the trailer towed back for storage. All but one of the host sites performed the above steps. Three host facilities stored the NoFoam Unit trailer while one activity kept the NoFoam Unit trailer outdoors at the designated nozzle discharge check site.

3.5 SAMPLING/MONITORING PROCEDURES

The four host facility fire-fighter operators performed the weekly NoFoam System nozzle discharge checks for each ARFF vehicle and recorded the flow results. NFESC reviewed the data entries for discrepancies and, if required, requested that the host activity repeat the ARFF vehicle nozzle discharge checks.

3.6 ANALYTICAL PROCEDURES

No analytical procedure was required for this project.

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4.0 PERFORMANCE ASSESSMENT

4.1 PERFORMANCE DATA

Ten ARFF vehicles platforms at four host activity sites were used during the NoFoam Unit demonstration and validation. The platforms and host sites were as follows:

- One P19 from MCAF Quantico, Virginia
- Two P19s from Tyndall AFB, Florida
- One P19 and one P300 from Fort Benning, Georgia
- Three CF4000Ls and two TA3000s from NAS Fallon, Nevada

The NoFoam Unit performed as expected to reduce or eliminate the AFFF wastewater from the routine nozzle discharge checks on all 10 working platforms. A minimum of 6 months of data was collected on the ARFF vehicle weekly scheduled nozzle discharge checks. The unit did not malfunction or break down during demonstration and validation. One host facility did not complete the 6-month collection of nozzle discharge checks because of problems with the multimetering valve, or proportioner, on the ARFF vehicles. The mechanics were not able to correct the problem because they lacked the proper parts.

4.2 PERFORMANCE CRITERIA

The NoFoam Unit technology expected performances at the four host activity sites are shown in Table 1.

4.3 DATA EVALUATION

The recorded discharge data flow rates closely matched the theoretical values of Table 2 and, on some occasions, identified problems with an ARFF vehicle foam distribution system. Further discussion is provided in the ESTCP Final Report (Kudo, 2003). The NoFoam Unit at times pinpointed the problems or gave indications of the problems. The unit gave the host activity fire chiefs, fire-fighter operators, and vehicle mechanics a higher confidence level in meeting their mission. One host activity installed the retrofit modules on all its ARFF vehicle inventory during the demonstration and validation period. Their facility vehicle mechanic performed the installation. Another activity backfitted their inventory at the end of the demonstration and validation period.

The NoFoam Unit was used as a diagnostic tool to evaluate the condition of the ARFF vehicle and identified problems with the vehicle foam distribution system. Initially, nine out of the 10 platforms showed problems with the vehicle foam distribution system—problems previously unknown to the fire-fighter operators and vehicle mechanics. The problems varied from debris entrapped in the foam distribution system to sticky and inoperable valve cylinders. The unit also helped to identify a wrong component installed in the vehicle foam distribution system and the wrong type of AFFF concentrate onboard the vehicle.

Table 1. Expected Performance and Performance Confirmation Methods for NoFoam Unit.

Performance Criteria	Expected Performance Metric (pre demo)	Performance Confirmation Method	Actual Performance (post demo)
Primary Criteria (Performance Objectives) (Quantitative)			
Product testing - Foam distribution system	Table 2	Operating experience	Table 2
Feed stream - Flow rates	Table 2	Flow meter and visual	Table 2
Hazardous materials - Eliminate - Generate	Reduce/eliminate AFFF wastewater None	Operating experience Operating experience	Reduced/eliminated AFFF wastewater None
Process Waste - Generated	None	Operating experience	None
Factors affecting performance (pollution prevention) - Nozzle discharge	Collect AFFF concentrate residuals	Operating experience	Collect AFFF concentrate residuals
Primary Performance Criteria (Performance objectives) (Qualitative)			
Better durability of part/ component	Nozzle discharge flow rate	Operating experience	Nozzle discharge flow rate
Less complex manufacturing		Operating experience	
Ease of use	Minimal operator training	Operating experience	Minimal operator training
Secondary Performance Criteria (Qualitative)			
Reliability	No breakdowns	Recordkeeping	No breakdowns
Safety - Hazards	Nozzle discharge	Operating experience	Nozzle discharge
Versatility - Intermittent operation - Other applications	Yes Yes, foam trailer	Operating experience Operating experience	Yes No, future demo
Maintenance - Required - Eliminated	Tire pressure, algae growth Replenish AFFF concentrate	Operating experience Operating experience	Tire pressure, algae growth Replenish AFFF concentrate

Table 2. Theoretical AFFF Concentrate Flowrates.

ARFF Vehicle Model	Station	Theoretical Flow Values	
		6% AFFF Concentrate (gallon)	3% AFFF Concentrate (gallon)
CF4000L	Roof	30	15
	Bumper	15	7.5
	Handline	3.6	1.8
	Undertruck	2.7	1.3
P19	Roof	30	15
	Bumper	15	7.5
	Handline	3.6	1.8
TA3000	Roof (high flow)	72	36
	Roof (low flow)	36	18
	Bumper	15	7.5
	Left - Handline	5.7	2.8
	Right - Handline	5.7	2.8
	Undertruck	3.0	1.5
P300	Roof (high flow)	90	45
	Roof (low flow)	45	22.5
	Bumper	18	9.0
	Left - Handline	5.7	2.8
	Right - Handline	5.7	2.8

4.4 TECHNOLOGY COMPARISON

The NoFoam Unit technology can be compared to the standard test procedures used to evaluate the foam fire-fighting equipment on ARFF vehicles, which conforms to the National Fire Protection Association (NFPA) document number NFPA 412 (NFPA, 1998). The foam quality is determined by capturing a sample of the foam solution with a device as directed by NFPA 412. The foam samples determine the conditional state of the vehicle foam distribution system. Large volumes of foam are generated while using NFPA 412. Table 3 illustrates that a large volume of AFFF wastewater is generated, as compared to the NoFoam Unit, which generates only minimal amounts of AFFF wastewater.

Table 3. Expected Generated AFFF Wastewater—30-Second Nozzle Discharge.

ARFF Vehicle Model	Generated AFFF Wastewater (gallon)
CF4000L	884
P19	840
TA3000	2435
P300	2,835

Table 4 shows the typical expected generated AFFF wastewater that the facility would see during the present foam distribution system nozzle discharge checks. Five seconds is chosen as the minimum amount of time to verify foam is emitted from any one nozzle.

Table 4. Expected Generated AFFF Wastewater—5-Second Nozzle Discharge.

ARFF Vehicle Model	Generated AFFF Wastewater (gallon)
CF4000L	528
P19	500
TA3000	1,460
P300	1,693

5.0 COST ASSESSMENT

5.1 COST REPORTING

An economic analysis was conducted on the NoFoam Unit using the Environmental Cost Analysis Methodology (ECAM) cost estimating tool (ECAM, ESTCP, NDCEE). The initial investment cost for a NoFoam Unit with three retrofit modules is $22,000, with an annual operating cost of $6,400. The annual operating cost without the NoFoam Unit technology is $170, 000, based on weekly ARFF nozzle checks. These cost are based on a full-scale NoFoam Unit.

5.2 COST ANALYSIS

The ECAM analysis for the NoFoam Unit net present value is $2,029,420 at 15 years, with an internal rate of return of 787.2% at 15 years, with a discounted payback of 0.13 years.

The NoFoam Unit can save annual disposal cost of $52,000 per vehicle based on weekly ARFF vehicle nozzle discharge checks (500 gallons AFFF wastewater per P19 at $2 per gallon for disposal). This translates to more than $62 million in annual savings for DoD's 1,200 ARFF vehicles. An additional cost avoidance of $1 million accrues because DoD will not have to purchase AFFF concentrate to perform foam distribution checks (2.2 gallons of AFFF concentrate per vehicle at $7 per gallon).

5.3 COST COMPARISON

The ECAM analysis indicates that the NoFoam Unit technology yields positive cost and environmental benefits. The facilities using this technology will yield an annual savings of $164,300 with an immediate payback.

The technology eliminates the wastewater generation from routine ARFF vehicle foam distribution system checks. This eliminates ground water contamination, waste treatment plant upsets, and disposal costs and reduces AFFF concentrate procurement. Additionally, it maximizes the facility's fire chief's and fire fighters' confidence level by ensuring that their ARFF vehicle functions properly—allowing them to meet their fire-fighting mission.

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6.0 IMPLEMENTATION ISSUES

6.1 COST OBSERVATIONS

The cost of a NoFoam Unit with three retrofit modules is $22,000. This includes the installation, testing, and training on the unit. As the firefighters become familiar with the unit, the time spent monitoring the ARFF vehicles will be reduced because of familiarity with unit operations. The site preparation requires covered stowage of the unit for extreme weather conditions.

6.2 PERFORMANCE OBSERVATIONS

Acceptance testing confirmed the ability of the NoFoam Unit to provide valid nozzle array discharge checks. At the same time the NoFoam Unit provided a reliable alternative to conducting standard ARFF vehicle foam distribution system testing, without the release of AFFF (Fischer and Kalberer, 2003).

6.3 SCALE-UP

The NoFoam Unit demonstrations and validations were conducted on full-scale applications on U.S. Marine Corps, U.S. Air Force, U.S. Army and U.S. Navy ARFF vehicles; therefore, no scale-up, performance-related issues exist.

6.4 OTHER SIGNIFICANT OBSERVATIONS

As stated in Fischer and Kalberer, 2003, and with NFESC installation experience, the unit may also be used to maintain and trouble-shoot the facility ARFF vehicle foam distribution system. Also, it could be used as a foam trailer for a rapid re-supply to ARFF vehicles during prolonged fire-fighting operations (Fischer and Kalberer, 2003).

6.5 LESSONS LEARNED

Valuable information was noted during demonstration and validation periods. Lessons learned, which would help a facility implement the NoFoam Unit, are listed below:

- Ensure that all personnel concerned with ARFF vehicles are involved with the funding, procurement, installation, testing, and training. This may include, but is not limited to, fire department, ARFF vehicle mechanics, environmental personnel, and transportation department. In many cases the facility transportation department is the custodian of the ARFF vehicle with the fire department using the equipment.

- On numerous occasions during start-up, the ARFF vehicle discharge checks with the NoFoam Unit did not match the expected values of Table 2 and the discrepancy was assumed to lie with the NoFoam Unit. However, closer inspection of the ARFF vehicle foam distribution system revealed problems with the ARFF distribution system rather than with the NoFoam Unit. In other words, the operator who performs the ARFF vehicle nozzle checks must trust what the NoFoam Unit indicates.

6.6 END-USER/ORIGINAL EQUIPMENT MANUFACTURER (OEM) ISSUES

The selected four host facility sites' firefighters and mechanics performed the weekly ARFF vehicle nozzle discharge checks while recording and collecting the data. They also recommended improvements to the unit during the demonstrations and validations, which were incorporated into the NoFoam Unit final design.

Two out of the four host facility sites backfitted their ARFF vehicle inventory. One site installed the retrofit modules on three vehicles and had their mechanic install the retrofitted modules during the demonstration and validation period; the other host site installed their three-ARFF-vehicle inventory at the completion of the demonstration and validation period. A third host requested additional retrofit module for testing, which their mechanic installed (Fischer and Kalberer, 2003).

The unit is available through the DoD Tri-Service Pollution Prevention Equipment Program (PPEP). In fiscal year 2002, five units were bought and installed through PPEP. In fiscal year 2003, seven units are planned for installation as seen in the NoFoam Unit implementation data package (Kudo and Buehler, 2001).

NFESC has a contract license with J.R. Thomas International, Inc., for the exclusive rights to commercialize the NoFoam Unit for ARFF vehicle technology (NFESC, 2003).

6.7 APPROACH TO REGULATORY COMPLIANCE AND ACCEPTANCE

No new or additional permits are required for the NoFoam Unit technology.

Every DoD facility and private industry facility must continue to emphasize the need to reduce hazardous waste generation. Additionally, when a new technology shows promise towards this goal, it is should be investigated.

7.0 REFERENCES

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APPENDIX A

POINTS OF CONTACT

Point of Contact	Organization	Phone/Fax/E-mail	Role in Project
Rance T. Kudo	NFESC ESC421 1100 23rd Avenue Port Hueneme, CA 93043	(805) 982-4976 Fax: (805) 982-4832 rance.kudo@navy.mil	Principal Investigator
Ray J. Cappillino	NFESC ESC421 1100 23rd Avenue Port Hueneme, CA 93043	(805) 982-1478 Fax: (805) 982-4832 ray.cappillino@navy.mil	Technician
Andrew S. Drucker	NFESC ESC423 1100 23rd Avenue Port Hueneme, CA 93043	(805) 982-1108 Fax: (805) 982-4832 andrew.drucker@navy.mil	Implementation
Brian E. Swaidan	NFESC ESC423 1100 23rd Avenue Port Hueneme, CA 93043	(805) 982-1337 Fax: (805) 982-4832 brian.swaidan@navy.mil	Implementation

ESTCP Program Office

901 North Stuart Street
Suite 303
Arlington, Virginia 22203

(703) 696-2117 (Phone)
(703) 696-2114 (Fax)

e-mail: estcp@estcp.org
www.estcp.org